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ABSTRACT

Most experts believe that young children possess a substantial amount of informal knowledge about mathematics. The teacher's role is to create a link between children's ability to use informal math and the ability to understand the more formal math taught in elementary school. Teachers must help children construct and elaborate upon what they already know, so they can "re-invent" mathematics for themselves. A reflective teacher helps the child discover and communicate ideas that would not have occurred spontaneously without the adult's help. This paper describes mathematics activities in two early childhood classrooms--a preschool class and a kindergarten class. Activities in the preschool class include children's books on counting, simple and repetitive songs, counting and spatial games, and learning centers such as the matching center and block center. The Kindergarten class uses a circus theme to cover topics such as number and measurement, sequence and ordering (time), measurement/weight, and part-part-whole. The paper then uses these descriptions to discuss important aspects of early childhood mathematics instruction, including the teacher's role and the development of spatial and number sense. Contains 13 references. (EV)

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EARLY CHILDHOOD MATHEMATICS

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Susan Sperry Smith

A group of three-year-olds sits in a circle, eagerly awaiting the story, *Puppy Says 1-2-3...* (Singer, 1993). They have not heard the tale of the puppy that counts and squeaks as their teacher, Miss Lily, squeezes his tummy. The class counts along with puppy. "Puppy looks up and what does he see? ONE little squirrel climbing up ONE big tree. Puppy says ONE."

Then the children play a game with three rubber cows, a mat of green "grass" and a bowl turned into a barn. One child says, "Let's put one cow on the grass. Let's put another cow on the grass. Now we have *two* cows." The cows go *into* the barn, *around* the barn and *on top of* the barn. The teacher gives them makeshift cardboard "bridges." The cows go *over* the bridge and *under* the bridge.

The teacher prepares many centers that are found throughout the room. Besides housekeeping, a picture-book center, a computer center, and a puzzle center, there are many centers devoted to early mathematical experiences. After much repetition the puppy book will go in the picture-book center to be read and reread. While the teacher knows that some of the children have been able to count to ten since the age of two, she realizes that very young children need a foundation with small sets, 1-2-3, emphasizing one-to-one correspondence. Later Miss Lily will introduce numbers up to five or ten.

During music, the class sings very simple songs with much repetition. Today they sing "Row, Row, Row Your Boat." The movement, the sound of the music, and the

lyrics reinforce pattern. Later in the year the children will construct simple patterns in artwork and with manipulatives.

MATHEMATICAL ACTIVITIES

The children choose a center to explore. The matching center contains bins of socks, mittens, identical farm animals, and zoo animals. The children put identical pairs together by type, not color. In the comparing center a child sorts stuffed animals into "big" and "little," with the teacher's help. Next week, the comparing center will feature a different pair of words. Some examples include:

Large-Small	Beach balls and tennis balls, toy dishes and real dishes, purses and luggage, doll clothes and adult clothes
Tall-Short	People, trees, skyscrapers, and houses
Fast-Slow	Songs played at different speeds, cars, children's actions
Heavy-Light	Rocks, empty and full milk cartons, feathers and blocks
Hot-Cold	Food, drinks, and the weather
Young-Old	Babies and grown-ups, trees
Loud-Soft	People's voices, musical instruments, recordings
High-Low	Playground equipment, airplanes and cars, people on balconies, musical instruments
Near-Far	People and things in different positions

Later in the week the class gathers in a circle to sort. They concentrate on things they know, such as food, toys, clothes, and ways to travel. They sort themselves by boy-girl, hair clips/no hair clips, buttons/no buttons, and so on. Miss Lily avoids categories that might cause hard feelings, such as a certain brand of tennis shoe vs. dress shoe.

In another session, Miss Lily introduces nesting toys that illustrate ordering. She asks the children to find the biggest one. The children point to the biggest cup. She takes it out of the line, places it near her, and asks, "Now which one is the biggest?" Miss Lily gathers various nested sets of measuring cups, kitchen bowls, plastic glasses, commercial nesting toys for her ordering center. Throughout the week children choose to visit this center and try to put the items in order.

In the pouring center a child fills plastic containers of many sizes with scoops of rice. The teacher helps with words like *empty/full* and *little/big*. The child fills the cup to the *top*. Later in the year the class will discuss "which jar has *more*, and which jar has *less*." A sturdy balance sits on the counter nearby. Children take turns weighing fruit, feathers, small items such as erasers, chalk, markers, crayons and toy cars. The child tells Miss Lily which items are *heavy*, and which are *light*.

The block-building center is a major center, and the cornerstone of a mathematically rich environment. Blocks are essential tools for creativity, dramatic play and geometry—for girls as well as boys. The teacher rotates groups of children to give everyone a chance. At first, a child might pile the blocks to make a tower, then make a simple enclosure, and eventually master the challenge of roofing or bridging the space between two walls. With time and practice children may build elaborate structures that have evidence of symmetry, sound construction, and aesthetics.

Developing Spatial Sense

Miss Lily understands that developing concepts about space is a natural part of growing up. She recognizes that children need opportunities to study the relationships between objects, places, and events (the study of topology) more than the ability to draw common shapes such as a circle or a square. The following examples (Smith, 1997) help children to understand the concept of space:

Large space	These spaces include playground, fields, or parks with equipment to climb, swing, slide, circle, and run. Gyms can also have enough space for running games, throwing balls, swinging on ropes, or jumping on trampolines.
Medium space	These spaces involve room or floor spaces that allow activities such as block building or housekeeping where children can climb inside the creations, or build a structure taller than themselves.
Small space	These spaced involve tabletop size buildings such as Legos, Duplos, regular Tinkertoys, and many manipulatives used as part of the math curriculum. The pieces generally fit in a child's hand.

Miss Lily creates opportunities to explore *proximity*, asking questions such as "Where am I?" or "Where is it?" *Separation* refers to the ability to see the whole object as comprised of individual parts. Puzzles and model building encourage this ability. The nesting center toys promote *order*, including reversing one's thinking. Miss Lily also talks about last week's events as well as what is happening today.

Enclosure refers to being surrounded or boxed in by the surrounding objects. The points on either side can enclose a point on a line. In three-dimensional space, a fence can enclose the animals, or a canister with a lid can enclose the cereal. The teacher helps by

saying, "Is the lid closed so the beads won't spill out?" or "Open the closed door so we can hang up our coats."

All of these activities contribute to the overall development of a child's *spatial* sense. In its 1989 *Curriculum and Evaluation Standards for School Mathematics*, the National Council of Teachers of Mathematics (NCTM) defines spatial sense this way:

> Spatial sense is an intuitive feel for one's surroundings and the objects in them. To develop spatial sense, children must have many experiences that focus on geometric relationships: the direction, orientation, and perspectives of objects in space, the relative shape and sizes of figures and objects, and how a change in shape relates to a change in size. (p. 49)

Spatial sense contributes to the study of geometry, and is an integral part of the preschool curriculum.

THE TEACHER'S ROLE

Most experts believe that young children possess a substantial amount of informal knowledge about mathematics. The teacher's role is to create a link between their ability to use informal math and the ability to understand the more formal math found in grade school (Ginsberg, 1996).

Teachers must help children construct and elaborate upon what they already know, so they can "re-invent" mathematics for themselves. A reflective teacher helps the child discover and communicate ideas that would not have occurred spontaneously without the adult's help (Vygotsky, 1978). As children mature they find patterns and

solve problems far beyond what is typically found in the preschool-kindergarten curriculum (Resnick, et. al., 1991, Carpenter, et. al., 1993).

Developing Number Sense

Number sense is using common sense based on the way numbers and tools work within a given culture. It involves an appreciation for the reasonableness of an answer and the level of accuracy needed to solve a particular problem. It is a complex set of interrelated concepts (Smith, 1997), including:

- Reading numerals, for example, it's a "three"
- Writing numerals, a visual-motor task
- Matching a number to a set, or the principle of cardinality, that is, counting 5 beans and answering the question, "How many?"
- Having an intuitive feel for how big a number is, that is "Is 15 closer to 10 or to 50?"
- Being able to make reasonable guesses using numbers, that is, the small jar could not hold more than 100 goldfish crackers
- Seeing part-whole relationships using sight or abstract thinking (without counting), that is, "I have 2 green bottle caps and 3 purple bottle caps."

The teacher facilitates the development of number sense and spatial sense throughout the preschool years.

THE KINDERGARTEN PROGRAM

Mr. Toby has a kindergarten class of fifteen students. At the beginning of each day they place a picture of themselves (that has been glued to a magnetized orange juice lid) on the attendance chart. The children count and decide how many people are here today and how many are absent. They decide if there are more boys than girls, or vice versa, and figure out the difference. They chart the weather for today by placing a magnetized counter under the category chosen: sun, clouds, rain, snow. They know that they can only choose one at a certain time in the morning.

They sequence the day's activities in a pocket chart. Mr. Toby knows that young children cannot comprehend the traditional calendar, i.e., a five-row and seven-column matrix, with both ordinal and cardinal numbers (Schwartz, 1994). He will gradually use a weekly schedule and then a two-week schedule before introducing a more comprehensive calendar. The children keep track of how many days they have been in school by putting a straw for each day in a container labeled the 1's cup. When there are ten straws in the cup, they bundle them and move them to the 10's cup. Sometime in February there will be ten groups of ten straws to move to the 100's cup, and the class will celebrate the 100th day of school. They will decorate a cake with 100 candles and have a party with a "GORP" mix consisting of small snack items (raisins, cereal, chocolate chips, etc.) that the students bring from home and sort into groups of 100. They will enjoy a day filled with many activities using 100 items.

The circus is a popular kindergarten theme. Over several days the class will participate in many creative art, creative movement, science, dramatic play, and cooking activities. A teacher plans a number of math activities, including the following:

Number and Measurement

Peanut Perimeter

Materials: Peanuts in the shell, a large bowl for each pair of students, small tables.

1. In pairs, the children decide how to line the edges of a small table with peanuts. They pay close attention to covering the edge and having the peanuts touch.
2. After they finish the perimeter, the children remove the peanuts while counting them with the teacher. Kindergarten children enjoy counting to 100 and beyond. (It may take over 100 peanuts for some tables.)

Sequence and Ordering (Time)

Mirette's Story

Materials: The book, *Mirette on the High Wire.* (McCully, 1992).

1. Read and reread the story of Mirette, and highlight the events in sequence:
   a. Mirette lives in a boarding house.
   b. A new tenant, a retired high wire performer, arrives.
   c. He teaches Mirette to walk the high wire.
   d. He returns to the stage.
2. Have the class act out and retell this story in sequence.

Measurement - Weight

How much Does a Baby Elephant Weigh?

Materials: Pictures of things that are very heavy, like a baby elephant, and very light—poster board or bulletin board.

1. Research the weight of a baby elephant. Compare it to the weight of a newborn person.

2. Make a more-less weight chart, with pictures of things that might weigh more or less than a baby elephant.

Part-Part-Whole—The Number 6

Mixed Nut Designs

Materials: Nuts in the shell, such as peanuts, almonds, walnuts, and pecans (any nuts that do not roll); a bowl; a large table or a rug.

1. Make design with two kinds of nuts, so that each design has six nuts.

2. Fill the whole table with designs, and tell the teacher about your combinations, for example, "This one has two pecans, and four peanuts. It looks like a star."

(For additional activities see Smith, 1997)

Mr. Toby concentrates on pattern-work, and part-part-whole designs with each number from 4 to 12. Later in the year he will introduce simple story problems, following the Cognitively Guided Instruction Approach (Carpenter & Moser, 1983; Carpenter & Moser, 1984; Carpenter, Carey, & Kouba, 1990; Peterson, Fennema, & Carpenter, 1989). Many kindergartners are able to solve problems such as those found below, using counters, their fingers or drawing:

- *The circus ring had three clowns. Four more clowns join them. Now how many clowns are in the ring?*

- *The clown had nine pieces of candy. He gave away four pieces. How many pieces does the clown have left?*

Some kindergarten children can also solve simple multiplication (repeated addition) and simple division (repeated subtraction) problems such as:

- *The clown had three bags of candy. There were five pieces of candy in each bag. How many pieces did the clown have?*
- *The clown had twelve pieces of candy. He gave three pieces to each child. How many children received candy?*

Mr. Toby's classroom provides the time and structure needed to explore significant mathematics. He encourages his students by respecting and valuing their ideas and validating their ways of thinking. He challenges the class to take intellectual risks by posing interesting questions to the group. They learn to support their responses with mathematical ideas. Finally, he encourages all students to participate so they gain confidence in their ideas.

All preschool and kindergarten teachers must pay attention to the key ingredients for success: a well-prepared environment, a developmentally appropriate math curriculum, and an awareness of the teacher's role. The process of learning is never over, but the journey is worth taking.

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